MIRA Manual - v. 1.4

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Description - about this document:
This manual describes MIRA, a **M**ultichannel **I**maging and Calibration Software for **R**eceiver **A**rrays. At present (September 2005), MIRA succeeds OTFCAL for the calibration of the new IMBFITS raw data at the 30m telescope.

Related documents:
http://www.iram.fr/IRAMFR/GILDAS/

1 Preface

MIRA as in the current version is still under development. Parts of its capabilities depend on the work done for other program libraries (CLASS90, TELCAL, PAKO). Comments and suggestions from users are welcome, and will be a valuable tool to further improve MIRA.

MIRA in its current version is exclusively used to reduce data written in the new IMBFITS raw data format. For old raw data, the old data processing software (OTFCAL) will be kept and maintained.

As soon as MIRA is fully integrated into as the standard heterodyne data processing software for the new control system, it will further evolve to provide tools for imaging with heterodyne receiver arrays.

This is a summary of recent changes in MIRA:

Version 1.1

- For online data processing, a prototypical procedure `mira_pro:reduce.mira` has been commited to the CVS.
- New default for `MIRA\CAL`: the calibration parameters of *all* frontend-backend combinations are computed.
- Output message formats for `MIRA\SCAN` changed.
- Calibration parameters are already computed and issued when a chopper-wheel calibration is loaded. For spectrometers with several basebands, mean values are given (for basebands belonging to the same spectrum).
- Command syntax for `MIRA\VIEW` changed to
  `MIRA\VIEW [ifb] [/CAL] [/GAINS] [/PHASES] [/SIGNAL] [/MAP]`
  Useful defaults are provided.
- Command syntax for `MIRA\SOLVE [pointing|focus] [ifb]` changed to `MIRA\SOLVE [ifb]`. Whether a pointing is to be solved or a focus is automatically determined from the observing procedure of the current scan.
- MIRA commands using the SIC macros in `mira_pro:p_plot_*.mira` can now be retrieved from SIC's command stack (concerns `MIRA\SOLVE` and `MIRA\VIEW`).
- `MIRA\SOLVE`: for pointings, the execution can be halted after the subscan fits with QUIT.
- MIRA command FIND has a new option `FIND /NEW` (for online data processing). Only new data are put into the index list. If no new data are found, the index list remains unchanged.
- Lists of MIRA commands FIND and LIST: by default, a "short" list is provided (without frontend names and spectral lines). The previous "long" list can be retrieved with the new option `LIST /LONG`. The telescope name is suppressed in any case. Note that the scan number is now listed in the first column, and the observation number in the last one.
- The information is the current index list can now be retrieved from the new SIC structure list (type `\MIRA\VARIABLE LIST r`).

- Support of old raw data abandoned.

Version 1.2

- Default for MIRA command CAL is now the first frontend-backend combination. If all frontend-backend combinations are to be calibrated, the argument ALL has to be specified, i.e. CAL ALL [/...options].
- The option /OFF of MIRA command CAL now offers several modi for the subtraction of the reference signal in OTF maps with total-power mode. The reference signal is either a mean of all off-measurements (option NONE, the default), an unweighted mean of the reference measurements taken before and after the on-measurement, and weighted means (weighting by total power or elapsed time). See the MIRA language internal help for more details.
- MIRA command WRITE, option /FEBE has a new argument: `MIRA\WRITE` *number* `/FEBE ALL` writes all frontend-backend combinations into the CLASS output file, starting with the observation identification *number* (if specified, otherwise successively increased by default).

Version 1.3

- MIRA stability is improved. If, for a given scan, the imbFits file of one of the backends is faulty, this backend will be ignored in the index list (and a warning message is issued).
- The new imbFits keywords `XOFFSET`i and `YOFFSET`i (with $i = 1$ to n_{offsets}, where n_{offsets} is the number of offsets from the catalogue position) are accomodated in MIRA's `SCAN%DATA` section.The resulting offset is in `SCAN%HEADER`.
- The SIC macro `reduce.mira` now becomes `reduceCont.mira` and `reduceSpec.mira`. See section 2.1 for details.
- New option `/ZOOM` for command `MIRA\VIEW`. First the data is fully shown, and the interactive cursor is called to define a rectangle to be zoomed in. The axis labels are correspondingly updated.
- `MIRA\VIEW /MAP /ZOOM` can be used to plot a subset of data. In the subset display, the range of `ON` positions covered by the subscan(s) is indicated.
- `MIRA\CAL`, option `/OFF`: the default weight mode for on-the-fly maps is now `AVER` (taking an average of all available off-source subscans). Option `NONE` does not remove any off-source signal, but concatenates the spectral basebands.
- MIRA's SIC variable `ARRAYi\%DATAj\%ISWITCH` (with `i` frontend-backend number, `j` baseband number) now becomes an array of character strings (instead of integer flags). See section 5 for details.

Version 1.4

- The header information provided by MIRA's command VIEW has been extended.
- `MIRA\CAL`: if the setup of the backends used for an observation is not strictly the same as for the previous (or, for offline data processing, the subsequent) calibration, MIRA complained about an inconsistent calibration. In version 1.4, MIRA looks whether a calibration is available for exactly the same spectral charactersistics. If so, the calibration is applied, even if the number of the backend part has changed. If no calibration with the same spectral characteristics is available, MIRA issues a warning, and flags those data as uncalibrated.
- Ambigeous scan numbers: it may happen that a raw data directory contains data from different observing dates, but with the same scan numbers. Until now, the only way out was to preselect the data in the index list, using `FIND /OBSERVED`. Otherwise, MIRA entered into a state of confusion and crashed when such a scan was read with `MIRA\SCAN`. In version 1.4, this is not so anymore: in case of ambigous scan numbers, the user is asked to enter the desired observing date (if nothing is entered, `MIRA\SCAN` returns to the command prompt, allowing to opt for the solution using `FIND /OBSERVED`.
- The pause between pointing solutions by subscans and coadded subscans, respectively, makes automatic online data processing impossible, since MIRA waits for the use to type `continue`. So, the pause was switched off in version 1.3. In version 1.4, it can be activated using MIRA's logical flag `doPause` (yes or .true. for interactive offline MIRA sessions, if the user wants to have a close look at the pointing subscans).
- Sometimes there are still spikes in the pointings (although usually lower than or comparable to the signal). MIRA's despiking routine works best after calibration, and the spikes get attributed a blanking value. Therefore, the `MIRA\SOLVE` command has been upgraded to correctly handle blanked values for either backend counts or equivalent temperature scales.
- slight syntax change for `MIRA\VIEW /PHASE idPhase irec`. `idPhase` can be one of the character strings `ON, OFF, LOAD, SKY, HOT, COLD, FLO, FHI`. The specified phase is averaged across the whole scan, unless a special record is specified with `irec`.
- If a backend part is disconnected, keeping the others, MIRA will work even if there will be a "hole" in the associated frontend-backend numbers (e.g. using VESPA parts 1, 3 and 4). Not yet tested for more than one backend part lacking.

2 MIRA online use

This section contains first thoughts how MIRA can be integrated in an online data processing scheme for visualizing and writing calibrated data.

2.1 Display the most recent results from MIRA

For online data display, I propose to start two MIRA sessions, one for continuum data, and one for spectra. This has the advantage that the last pointing and focus measurements are displayed, while the spectra observed afterwards are also shown on a separate screen. The complication of opening two graphic devices from the same MIRA session (potentially unstalbe) is thus avoided. The syntax for online data display is

```
@ reduceCont iRef writeClass
```

for the continuum backends, and

```
@ reduceSpec iSpec writeClass
```

for the spectrometers. `iref` is the reference frontend-backend combination for pointing and focus fits, `ispec` specifies the frontend-backend combination of the spectrum to be shown, and `writeClass` is a logical flag deciding whether a CLASS file is to be written or not. I propose to set `writeClass` to `.false.` (or `no`), and to leave the generation of a CLASS file to a dedicated Python script (see below).

2.2 Online generation of calibrated CLASS spectra

MIRA should be called (scan by scan) from the NCS via a Python script that reads in the scan needed, calibrate it, write a CLASS spectrum (e.g. spectraOdp.30m) to a default output directory. As usual, the respective project directory contains a soft link data.30m pointing to spectraOdp.30m.

3 A typical (offline) data reduction session

For the sake of a cookbook recipe, here is an example of a MIRA session.

`file in "/ncsServer/mrt/ncs/data/2005-04-06"`	opens the input directory for reading
`file out spectra.30m new`	opens output file for calibrated data (CLASS forma
`find /observed 2005-09-06 /scan 5 15`	only puts scans 5 to 15 from September 6 into the index list.

... and yields the following list (with column 1 - scan number, column 2 - object, column 3 - observing procedure, column 4 switch mode, column 5 - backend name, column 6 - date of observation, column 7 - observation number) :

```
  5 VENUS      calibrat     beamSwitching     CONTI   2005-09-06    1
  6 VENUS      pointing     beamSwitching     CONTI   2005-09-06    2
  9 VENUS      focus        beamSwitching     CONTI   2005-09-06    3
 12 IRC+10216  calibrat     beamSwitching     4MHZ    2005-09-06    4
 13 IRC+10216  onOff        beamSwitching     4MHZ    2005-09-06    5
 14 IRC+10216  calibrat     beamSwitching     4MHZ    2005-09-06    6
 15 IRC+10216  onTheFly     totalPower        4MHZ    2005-09-06    7
```

The same list can be displayed with MIRA command LIST, which also allows to write it to an output file and not to the screen (option /OUTPUT), and to issue information on the frontends connected and spectral lines observed (option /LONG).

A typical data reduction session looks like this:

`scan 5` loads scan 5 (calibration), computes the calibration paramters, and issues the following information:

```
FeBe Number              Frontend                  Backend

     1                     A100                     CONTI
     2                     B100                     CONTI
     3                     A230                     CONTI
     4                     B230                     CONTI


idFe THotLoad TColdLoad idBe  Pix  recTemp sysTemp calTemp tauZenith pwv
     ---- [Kelvin] ----            ------ [Kelvin] -------  [Neper]  [mm]
-------------------------------------------------------------------------
A100  295.199    86.000 CONTI  1     78.60  480.33  228.15    7.29   10.1
B100  295.199    88.000 CONTI  1     39.91  404.02  216.94    7.31   11.9
A230  295.199    86.000 CONTI  1    289.67 1515.64  350.22    0.39    5.6
B230  295.199    86.000 CONTI  1     91.00  800.64  305.18    0.43    6.2
```

`scan 6` loads scan 6 (a pointing on Venus)

Tip: It may happen that your index list contains observations from different days, but with the same scan number. In that case, comand SCAN invites you to enter the wanted date of observation (format YYYY-MM-DD). Alternatively, if you enter nothing, you return to MIRA's command line, where you can narrow your search criteria with FIND /OBSERVED YYYY-MM-DD.

`cal all` corrects all observations in the current scan for gains, applies the Ta* scale and subtracts off signals. N.B. CAL is NOT a prerequisite for solving pointings or foci.

`solve 4` solves the pointing measurement, using the receiver B230, plots the results (Fig.1, 2), and writes an XML file for the control system.

Tip: Occasionally, spikes appear in the raw data. If they are stronger than the total power level, they can be removed from the raw data with MIRA's command DESPIKE. If they are comparable to the total power level, you should first calibrate the pointing, then despike, and then solve the pointing fit.

Tip: By default, MIRA's pointing procedure halts for a while after the subscan plots, and then displays the results of the coadded azimuth respectively elevation subscans. This is for online data processing. For offline data processing, you may want to have a close look at the subscans. In that case, please enter **LET doPause yes**.

`scan 9`	loads scan 9
`solve 1`	solve and plot the focus for receiver B230 (Fig.3), and writes an XML file for the control system.
`scan 12`	loads scan 12 (a calibration for the 4MHz filterbank), and issues

```
FeBe Number              Frontend                  Backend

     1                     A230                     4MHZ
     2                     B230                     4MHZ


idFe THotLoad TColdLoad idBe  Pix  recTemp sysTemp calTemp tauZenith pwv
     ---- [Kelvin] ----           ------ [Kelvin] -------  [Neper]  [mm]
-------------------------------------------------------------------------
A230  295.199    86.000 4MHZ   1    362.19 3018.86  240.79    0.40    5.8
B230  295.199    86.000 4MHZ   1    127.34 1658.64  213.17    0.42    6.0
```

`scan 13`	loads scan 13 (an on-off on IRC+10216)
`view [1 /phases ON]`	plots the uncalibrated spectrum of the A230 receiver. The text in brackets is the default for `\view` (uncalibrated data).
`view 1 /phases OFF`	You may want to look e.g. at the off-phase, too.
`cal all`	calibrates the spectra of both the A230 and B230 receivers.
`view [1 /signal]`	plots the calibrated spectrum for the A230 receiver (Fig.4). The text in brackets is the default for `\view` (calibrated data).
`write /febe ALL`	writes the calibrated spectra into the output file for CLASS (starting with observing number 1)

MIRA offers possibilities to plot calibration counts, gainarrays of spectrometers, raw data (individual phases of the switch cycle), calibrated data (as spectra or pseudo-maps for OTF). For details, please have a look at section 4.

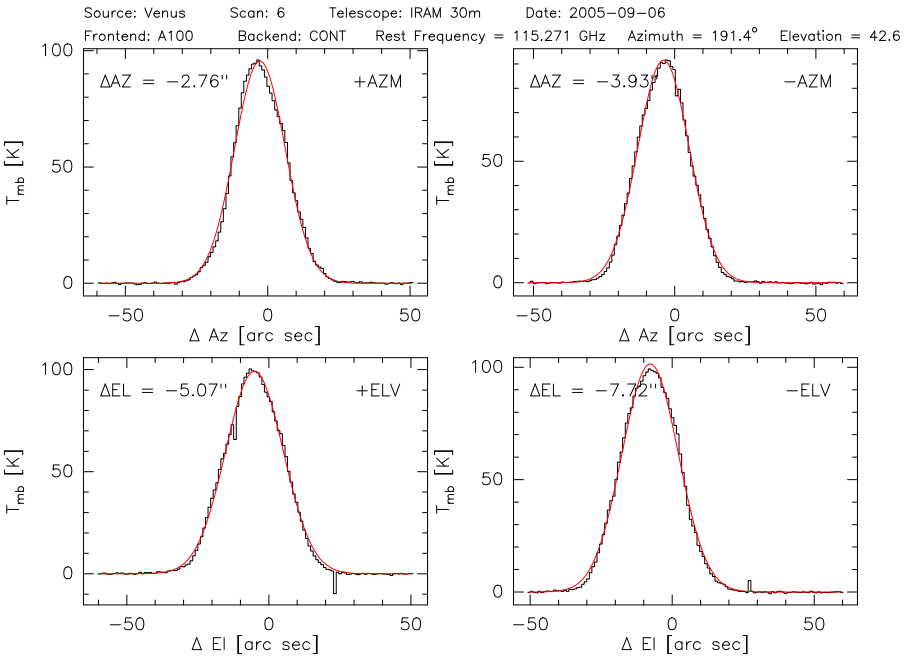
Source: Venus Scan: 6 Telescope: IRAM 30m Date: 2005−09−06
Frontend: A100 Backend: CONT Rest Frequency = 115.271 GHz Azimuth = 191.4° Elevation = 42.6
ΔAZ = −2.76'' +AZM
ΔAZ = −3.93'' −AZM
ΔEL = −5.07'' +ELV
ΔEL = −7.72'' −ELV
T_mb [K]
Δ Az [arc sec]
Δ El [arc sec]

Figure 1: Example for a pointing solution (first step).

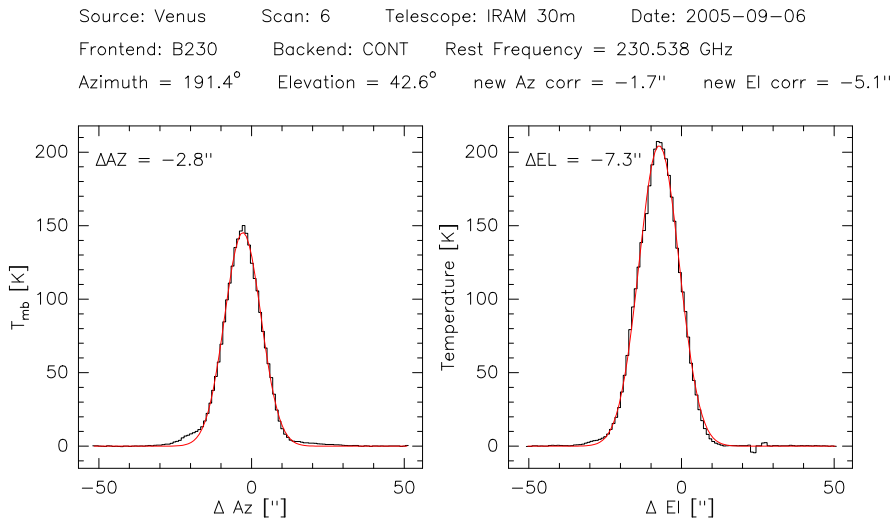
Source: Venus Scan: 6 Telescope: IRAM 30m Date: 2005−09−06
Frontend: B230 Backend: CONT Rest Frequency = 230.538 GHz
Azimuth = 191.4° Elevation = 42.6° new Az corr = −1.7'' new El corr = −5.1''
ΔAZ = −2.8''
ΔEL = −7.3''
T_mb [K]
Temperature [K]
Δ Az ['']
Δ El ['']

Figure 2: Example for a pointing solution (subscans coadded).

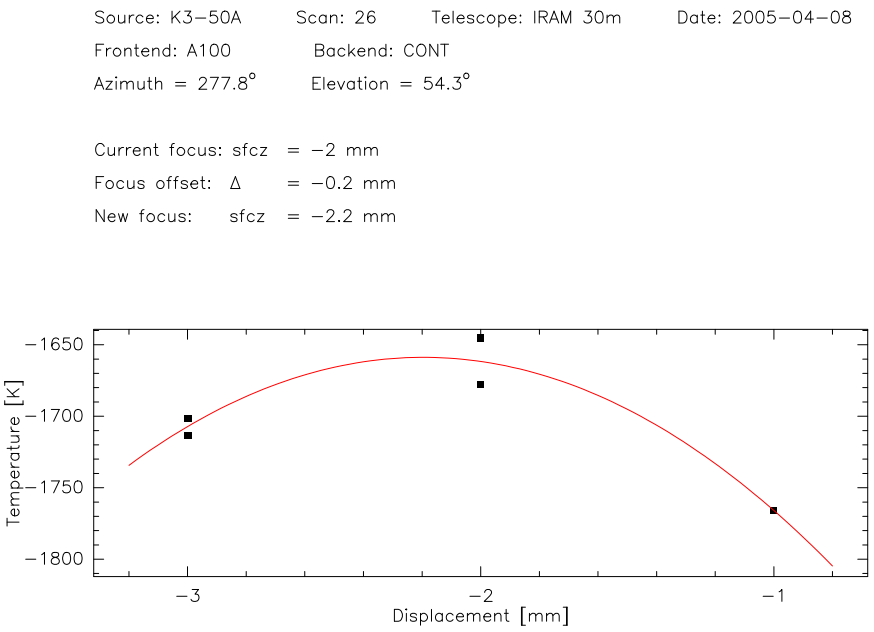

Figure 3: Example for a focus solution.

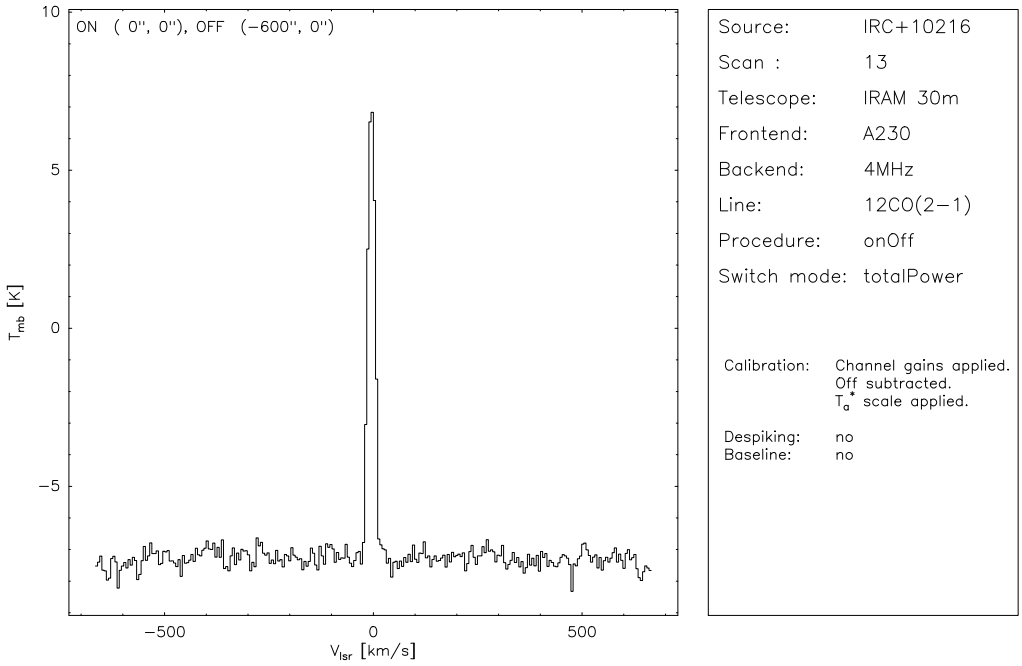

Figure 4: Example of a calibrated spectrum.

4 MIRA language internal help

4.1 CAL

```
MIRA\CAL [ALL|ifb] [/GAINS [/TCAL]]
      [/OFF [NONE] [AVER] [EQUAL] [TIME] [TOTAL vMin vMax]]
```

CAL calibrates the raw data of the observations loaded with MIRA\SCAN. By default, the first frontend-backend combination is calibrated, otherwise the frontend-backend combination number ifb, or all frontend-backend combinations if ALL is specified instead. If no option is specified, all three calibration stages are performed (i.e. normalization by channel gains, conversion from backend counts to a temperature scale, subtraction of the off-signal with concatenation of autocorrelator basebands.

CAL /GAINS normalizes the spectral band by the gainarray.

CAL /TCAL Converts from backend counts to temperature (forward beam brightness temperature if beam efficiciency set to forward efficiency, otherwise main beam brightness temperature), using the TCal scale automatically determined when a "chopper wheel" calibration is loaded.

CAL /OFF subtracts the atmospheric emission as measured on the OFF position, and concatenates spectral basebands. For frequency-switched observations, the subtraction of the reference signal has to be done in CLASS with command FOLD.

For on-the-fly data in total power mode, CAL /OFF has the following options:

CAL /OFF NONE does not subtract the reference signal, only concatenates spectral basebands.

CAL /OFF AVER uses as reference signal for off subtraction the unweighted mean of all available reference measurements. This is the default.

CAL /OFF EQUAL uses as reference signal an unweighted mean of the off-measurements taken before respectively after the on-subscan.

CAL /OFF TIME uses as reference signal a weighted mean of the off-measurements taken before respectively after the on-subscan. The first reference has a weight decreasing with the time elapsed between the on-the-fly record and the first reference measurement (and the weight of the second reference increases correspondingly).

CAL /OFF TOTAL vMin vMax uses as reference signal a weighted mean value

of the off-measurements taken before respectively after the on-subscan. The weighting is done in a way to ensure that the total power of the on-the-fly record equals the total power of the reference signal. A spectral line contributing significantly to the total power can be masked with the arguments vMin and vMax.

4.2 DESPIKE

```
MIRA\DESPIKE [ifb] [/PIXEL [ipix]] [/ITERATE niter] [/INTERPOLATE]
```

DESPIKE removes spikes from spectra, OTF data, and continuum drifts, respectively. If the frontend-backend identification number ifb is not specified, the first frontend-backend combination of the current scan is despiked.

DESPIKE /PIXEL [ipix]
Allows to specify the pixel number ipix (for HERA data). Default is pixel 1.

DESPIKE /ITERATE niter
Allows to remove up to niter spikes (default is niter = 10).

DESPIKE /INTERPOLATE
Instead of attributing the blanking value to the removed spikes, the mean value of the next neighbours is used. Not yet implemented.

4.3 FILE

```
MIRA\FILE IN|OUT name [NEW] [/CLASS] [/MBFITS]
```

```
Selects the input directory and output files.
FILE IN name         defines the input directory
FILE OUT name [NEW]  defined the output file;
                     initializes a file if NEW is given.

FILE /CLASS Opens a CLASS type file for output (default).

FILE /MBITS Converts IMBFITS raw data to MBFITS raw data.
            Not yet implemented.
```

4.4 FIND

```
MIRA\FIND [/BACKEND] [/FRONTEND] [/LINE] [/OBSERVED] [/PROCEDURE]
       [/SCAN] [/SOURCE] [/TELESCOPE] [/NEW] [/SWITCHMODE]
```

FIND performs a search in the input directory to build a new index, according to selection criteria defined by one or more of the following options. The index list (as desribed in the help for command MIRA\LIST).

/BACKEND name	Searches for data from backend name.
/FRONTEND receiver	Searches for data from a given receiver.
/LINE transition	Search for data of spectral line transition.
/OBSERVED startDate [endDate]	Searches for data observed between startDate and endDate. If endDate is not specied, looks only for data observed the day of startDate. Date format is YYYY-MM-DD (e.g. 2005-09-29).
/PROCEDURE procedure	Searches for data of a given observing procedure (e.g. pointing, focus, onOff, calibration,...).
/SCAN i1 [i2]	Searches for data from scans i1 to i2 (or only scan i1 if i2 not specified).
/SOURCE object	Searches for data from source object.
/TELESCOPE antenna	Searches for data from telescope antenna.
/NEW	Searches for new data written to the input directory; the new index list will only contain new data. If no new data are found, the current index list remains unchanged. For online data processing at the telescope.
/SWITCHMOD switch	Searches for observations done with switchmode switch (e.g. wobbler, beamSwitching).

4.5 LIST

```
MIRA\LIST [/OUTPUT listfile] [/LONG]
```

LIST writes the current index list to the screen:
column 1 : scan number
column 2 : source name
column 3 : observing procedure
column 4 : switch mode
column 5 : backend name
column 6 : observing date (format YYYY-MM-DD)
column 7 : running index

LIST /OUTPUT listfile	Writes the index list into output file listfile, instead of writing to the screen. No default provided (LIST /OUTPUT has the same action as LIST). Default extension is .lis
LIST /LONG	Provides a more complete listing. Each frontend-backend combination is listed. Information which is the same for all frontend-backend combinations is only written once per scan (all columns except for the spectral line name and the frontend name).
column 1:	scan number
column 2:	source name
column 3:	spectral line name
column 4:	observing procedure
column 5:	switch mode
column 6:	frontend name
column 7:	backend name
column 8:	observing date
column 9:	running index

4.6 SCAN

MIRA\SCAN scan

Loads a scan from the current index list. ALL frontend-backend combinations used are loaded. A list of identification numbers for the frontend-backend combinations is issued. For calibrations, MIRA\SCAN also computes the calibrations parameters, and writes them to the screen. The calibration parameters for VESPA basebands are individually computed; however, the screen output is for mean values across all basebands corresponding to one spectrum.

4.7 SOLVE

MIRA\SOLVE [ifb] [/PIXEL ipix] [/BINNING nbin]

SOLVE retrieves the pointing respectively focus corrections from the observing procedure loaded with MIRA\SCAN. By default, the first frontend connected to the continuum backend is used, otherwise number ifb. The results are written to the output device, and to output files miraResultsPointing.xml respectively miraResultsFocus.xml for further use

by the telescope's control system.

SOLVE /PIXEL ipix	For observations with HERA. Allows to specify another pixel than the reference pixel for pointing and focus.
SOLVE /BINNING nbin	For pointing measurements, allows to smooth the azimuth and elevations drifts (for weak pointing sources). nbin is the number of dumps averaged (simple box window smoothing).

4.8 VARIABLE

MIRA\VARIABLE section|* read|write

Generates a SIC copy of one of the following MIRA data sections (wildcard permitted, activates all sections), for read (default) ow write access. For further documentation on MIRA's data structure, please consult section 5 of the MIRA manual. The section MON consists of SIC structures MON%HEADER and MON%DATA. Each frontend-backend combination has its own GAINS and REDUCE section (e.g. GAINS1, REDUCE3, etc.). The sections SCAN, FEBE, and DATA consist of header and data structures for each frontend-backend combination, e.g. SCAN1%HEADER, SCAN1%DATA, FEBE2%HEADER, FEBE3%DATA, and so on. The DATA and HEADER structures of section ARRAY are written for each baseband, e.g. ARRAY1%HEADER1, ARRAY2%DATA3, etc.

VARIABLE PRIM	Retrieves the IMBFITS primary header.
VARIABLE SCAN	Same for the scan header and table sections.
VARIABLE FEBE	Information related to the frontend-backend combination.
VARIABLE ARRAY	Raw data headers and data sections.
VARIABLE DATA	For calibrated raw data, and monitor points interpolated at the backend timestamps.
VARIABLE MON	Monitoring headers and table sections.
VARIABLE GAINS	Calibration parameter for each frontend-backend combination.
VARIABLE CHOICE	Search options for MIRA's command FIND.
VARIABLE REDUCE	MIRA internal flags for calibration history.
VARIABLE LIST	Entries of the current index list.

4.9 VIEW

```
MIRA\VIEW [ifb] [/CAL] [/GAINS] [/PHASES [phaseId] [irec]] [/SIGNAL [idu
            [/MAP] [/ZOOM]
```

VIEW is MIRA's command for plotting the data of frontend-backend combination number ifb (default is 1). The item to be plotted is specified by one of the following options. Otherwise, the following defaults are provided: VIEW /CAL for chopper-wheel calibrations, VIEW /PHASES for all uncalibrated data, VIEW /SIGNAL for calibrated data (at least off subtracted) from a single position, respectively VIEW /MAP for OTF maps.

VIEW /CAL
For calibrations only. Plots the counts from the loads (sky, ambient, cold, respectively) versus time (for continuum backends. For spectral line backends, plots the subscan average of the dumps from the corresponding loads versus frequency.

VIEW /GAINS
Plots the gainarray currently in use. For spectrometers only.

VIEW /PHASES [phaseId] [irec]
Plots the uncalibrated data against time (for continuum backends) respectively frequency and record number (for spectrometers), using phase phaseId (according to the observing procedure viewed, it defaults to 0 SKY, or FHI). By default, the scan average of all phases iphase in shown, otherwise record number irec.

VIEW /SIGNAL [idump]
Plots calibrated data, as time series (for continuum drifts) respectively spectra (for spectrometers). For OTF maps, record number idump can be specified to plot a single spectrum.

VIEW /MAP
Plots a pseudo-map (data values versus velocity and record number) for calibrated OTF data.

VIEW /ZOOM
Plots and calls the interactive cursor to define a region for a zoom. Use the cursor to define the lower left and upper right corner (order does not matter).

4.10 WRITE

```
MIRA\WRITE [number] [/FEBE ALL|ifb] [/PIXEL ipix] [/SUBSCANS isub]

Writes calibrated data to a CLASS file (respectively raw data to a
MBFITS file, not yet implemented, see help for MIRA\FILE). The number of
the spectrum (or continuum drift) written can be specified, otherwise it is
successively increased, starting at 1.

WRITE [number] /FEBE ALL|ifb
Specifies the frontend-backend combination to be written. Default is 1.
Writes CLASS spectra for all frontend-backend combinations in current index
(starting with observation identification 'number' if specified).

WRITE /PIXEL ipix
For HERA data: spectra from pixel ipix are written (default pixel 1).

WRITE /SUBSCANS isub
For continuum drifts and OTF maps: only data from subscan isub are written.
```

5 MIRA / SIC variables

Most of the variables in the internal MIRA structure can be copied to and examine (e.g. plotted with GREG) as SIC variables. MIRA provides the following commands for defining and initialising these variables. For an explanation of the sections and their contents, I also refer to the document "Multi-Beam FITS Raw Data Format", revision 1.4. Variables derived from WCS (= *world coordinate system*) FITS keywords have their leading number appended to the end of the keywords' names, for the sake for compatibility with FORTRAN (e.g. `CRVL4_1` instead of `1CRVL4`).

There are MIRA variables that are useful to customize plotting routines for online respectively offline use of MIRA, or for defining tolerance limits for tracking errors (to be done). In version 1.4, there is only one such variable:

```
doPause                    ! Logical GLOBAL
```

which can be set to `.true.` or `.false.` with

```
let doPause yes
```

respectively

```
let doPause no
```

It is used to halt the execution of `MIRA\SOLVE` until the user types `continue`.

`var prim r [w]`	retrieves primary header as SIC variables for reading (default) or writing.
`var scan r [w]`	same for the scan header and table sections
`var febe r [w]`	frontend-backend header and table sections
`var array r [w]`	arraydata headers and table sections
`var data r [w]`	data headers and table sections
`var mon r [w]`	monitoring headers and table sections
`var gains r [w]`	MIRA variables
`var choice r [w]`	search options for MIRA command `find`
`var reduce r [w]`	MIRA internal flags for calibration history

Here is a listing of the corresponding SIC variables. The array dimensions are specified by the following parameters:

$n_{\rm fb}$	number of frontend-backend combinations
$n_{\rm pix}$	number of pixels
$n_{\rm bd}$	number of basebands
$n_{\rm cpb}$	number of spectral channels per baseband
$n_{\rm chan}$	number of spectral channels (concatenated basebands)
$n_{\rm off}$	number of off positions from catalogue position
$n_{\rm rec}$	number of records (= backend data)
$n_{\rm ph}$	number of phases (e.g. 2 = on, off)
$n_{\rm subsc}$	number of subscans
$n_{\rm subr}$	number of subreflector monitor points
$n_{\rm slow}$	number of antenna monitor points (slow rate)
$n_{\rm fast}$	number of antenna monitor points (fast rate)

Variable types are denoted as S (structure), I (integer), R (real, single precision), D (real, double precision), C (character string) and L (logical).

Caveats: (1) Neither the MIRA data structures nor the corresponding SIC structures are exactly mapped from the MBFITS V1.54 file definition. However, I tried to keep them as close as possible. (2) Not all of the following items are already copied from the IMBFITS file to SIC variables (even if the SIC variable is declared).

5.1 PRIMARY section

PRIM	S	
PRIM%HEADER	S	
PRIM%HEADER%MBFTSVER	C*11	MBFITS version
PRIM%HEADER%CREATOR	C*32	Softwrae (including version)
PRIM%HEADER%ORIGIN	C*32	Organisation or Institution
PRIM%HEADER%TELESCOP	C*13	Telescope Name
PRIM%HEADER%EXTEND	L	
PRIM%HEADER%BITPIX	I	
PRIM%HEADER%SIMPLE	L	
PRIM%HEADER%NAXIS	I	

5.2 SCAN section

General scan information.

SCAN	S		
SCAN%HEADER	S		
SCAN%HEADER%ZFLX	R	deg	Pointing coefficient (Flexure)
SCAN%HEADER%ECEC	R	deg	Pointing coefficient (P8)
SCAN%HEADER%IE	R	deg	Pointing coefficient (P7)
SCAN%HEADER%AW	R	deg	Pointing coefficient (-P4)
SCAN%HEADER%AN	R	deg	Pointing coefficient (P5)
SCAN%HEADER%NPAE	R	deg	Pointing coefficient (P3)
SCAN%HEADER%CA	R	deg	Pointing coefficient (P2)
SCAN%HEADER%IA	R	deg	Pointing coefficient (P1)
SCAN%HEADER%NFEBE	I		number of frontend-backend combinations
SCAN%HEADER%WOBMODE	C*20		wobbler mode (SQUARE/TRIANGULAR)
SCAN%HEADER%WOBCYCLE	R	sec	wobbler period
SCAN%HEADER%WOBDIR	C*4		wobbler throw direction
SCAN%HEADER%WOBTHROW	D	deg	wobbler throw (can also be used for beam switching)
SCAN%HEADER%WOBUSED	L		Wobbler used ?
SCAN%HEADER%TRANFOCU	I	m	(optional, HOLO) transmitter offset from prime focus
SCAN%HEADER%TRANFREQ	I	Hz	(optional, HOLO) transmitter frequency
SCAN%HEADER%TRANDIST	I	m	(optional, HOLO) transmitter distance
SCAN%HEADER%ZIGZAG	L		(optional, OTF/RASTER) Scan in zigzag ?
SCAN%HEADER%CROCYCLE	C*20		CAL/REF/ON loop string
SCAN%HEADER%SCANPAR1	D		(optional) spare scan parameter
SCAN%HEADER%SCANPAR2	D		(optional) spare scan parameter
SCAN%HEADER%SCANSKEW	D	user def.	(optional, OTF/RASTER) offset in scan direction between lines

SCAN%HEADER%SCANYSPC	D	user def.	(optional, OTF/RASTER) step between scan/raster lines
SCAN%HEADER%SCANXSPC	D	user def.	(optional, OTF/RASTER) step along line between samples
SCAN%HEADER%SCANTIME	D	user def.	(optional, OTF) time for one line
SCAN%HEADER%SCANXVEL	D	user def.	(optional, OTF) tracking rate along line
SCAN%HEADER%SCANLEN	D	user def.	(optional, OTF/RASTER) line length
SCAN%HEADER%SCANRPTS	I		(optional) number of repeats of each scan line. Default 1.
SCAN%HEADER%SCANLINE	I		(optional) number of lines in a scan. Default 1.
SCAN%HEADER%SCANDIR	C*4		(optional) scan direction
SCAN%HEADER%SCANGEOM	C*20		Scan geometry
SCAN%HEADER%SCANMODE	C*20		Mapping mode
SCAN%HEADER%SCANTYPE	C*20		Scan astronomical type
SCAN%HEADER%DISTANCE	D	AU	geocentric distance
SCAN%HEADER%ORBEQUNX	D		Elements equinox: J2000.0 or B1950.0
SCAN%HEADER%ORBEPOCH	D	Julian days	EPOCH, Epoch of orbital elements
SCAN%HEADER%ECCENTR	D		EC, Eccentricity
SCAN%HEADER%INCLINAT	D		IN, Inclination
SCAN%HEADER%OMEGA	D		W, Angle from ascending node to perihelion
SCAN%HEADER%LONGASC	D		OM, Longitude of ascending node (in degrees)
SCAN%HEADER%PERIDIST	D	AU	QR, perihelion distance
SCAN%HEADER%PERIDATE	D	Julian days	TP, Full Julian date of perihelion passage
SCAN%HEADER%MOVEFRAM	L		True if tracking a moving frame. If true, the above orbital elements are stored.
SCAN%HEADER%CALCODE	C*4		Calibrator code
SCAN%HEADER%LATOBJ	D	deg	Source latitude in native frame.
SCAN%HEADER%LONGOBJ	D	deg	Source longitude in native frame.
SCAN%HEADER%LONGOFF	D	deg	Longitude offset from catalogue position.
SCAN%HEADER%LATOFF	D	deg	Latitude offset from catalogue position.
SCAN%HEADER%OBJECT	C*10		Source name.
SCAN%HEADER%LATPOLE	D	deg	Basis latitude of native pole.
SCAN%HEADER%LONPOLE	D	deg	Native longitude of celestial pole.
SCAN%HEADER%CRVAL1	D	deg	Native frame zero in basis system (long.)
SCAN%HEADER%CRVAL2	D	deg	Native frame zero in basis system (lat.)
SCAN%HEADER%EQUINOX	R	Julian years	Equinox
SCAN%HEADER%RADECSYS	C*32		additional system definition for ecliptic/ equatorial coordinates
SCAN%HEADER%CTYPE1	C*8		Basis system (longitude) XLON-SFL
SCAN%HEADER%CTYPE2	C*8		Basis system (latitude) XLAT-SFL
SCAN%HEADER%ETUTC	D	s	Ephemeris Time - UTC time translation
SCAN%HEADER%GPSTAI	D	s	GPS time - TAI translation
SCAN%HEADER%TAIUTC	D	s	TAI-UTC time translation
SCAN%HEADER%UT1UTC	D	s	UT1-UTC time translation
SCAN%HEADER%NOBS	I		Number of observations in this scan
SCAN%HEADER%LST	D	s	Local apparent sidereal time (scan start)
SCAN%HEADER%MJD	D	day	Scan start time (modified Julian date) in TIMESYS system
SCAN%HEADER%DATE_OBS	C*23		Scan date/time (in TIMESYS system)
SCAN%HEADER%SCANNUM	I		Scan number
SCAN%HEADER%OBSID	C*12		Observer and Operator initials
SCAN%HEADER%PROJID	C*12		Project ID
SCAN%HEADER%SITEELEV	R	m	Observatory elevation

SCAN%HEADER%SITELONG	D	deg	Observatory longitude
SCAN%HEADER%SITELAT	D	deg	Observatory latitude
SCAN%HEADER%TELESCOP	C*13		Telescope name
SCAN%DATA	S		
SCAN%DATA%LONGOFF	$n_{\rm off}$ D	deg	longitude offset from catalogue position
SCAN%DATA%LATOFF	$n_{\rm off}$D	deg	latitude offset from catalogue position
SCAN%DATA%FE	$n_{\rm fb}$ I		frontend ID of each frontend-backend combination 0 = unknown 1 = A100 2 = B100 3 = C150 4 = D150 5 = A230 6 = B230 7 = C270 8 = D270 9 = HERA 10 = HERB
SCAN%DATA%BE	$n_{\rm fb}$ I		backend ID of each frontend-backend combination 0 = unknown 1 = continuum 4 = VESPA 5 = WILMA 7 = 4MHz

5.3 FEBE section

There is one FEBE (=frontend-backend description) section per frontend-backend combination. The following list is for frontend-backend combination 1 (the corresponding items for combination 2 were FEBE2%HEADER and FEBE2%DATA, and so on).

FEBE1	S		
FEBE1%HEADER	S		
FEBE1%HEADER%ZFLXRX	R	deg	Pointing Coefficient (receiver), adds to ZFLX
FEBE1%HEADER%ECECRX	R	deg	Pointing Coefficient (receiver), adds to ECEC (P8)
FEBE1%HEADER%IERX	R	deg	Pointing Coefficient (receiver), adds to IE (P7)
FEBE1%HEADER%CARX	R	deg	Pointing Coefficient (receiver), adds to CA (P2)
FEBE1%HEADER%IARX	R	deg	Pointing Coefficient (receiver), adds to
FEBE1%HEADER%FRQTHROW	R	Hz	Frequency switching throw
FEBE1%HEADER%NPHASES	I		number of switch phases in a switch cycle
FEBE1%HEADER%SWTCHMOD	C*20		Switch mode
FEBE1%HEADER%NUSEFEED	I		number fo feeds in use.
FEBE1%HEADER%FEBEFEED	I		total number of feeds.
FEBE1%HEADER%FEBEBAND	I		total number of basebands for this frontend-backend combination
FEBE1%HEADER%DEWANG	R	deg	dewar angle
FEBE1%HEADER%DEWRTMOD	C*5		dewar tracking system
FEBE1%HEADER%DATE_OBS	C*23		observing date (Y2K format with time) in TIMESYS system (scan start)
FEBE1%HEADER%SCANNUM	I		scan number
FEBE1%HEADER%FEBE	C*17		frontend-backend combination identification

FEBE1%DATA		S		
FEBE1%DATA%GAINELE1	$n_{\rm bd}$	R	deg	Gain-elevation correction parameter 1 (see MBFITS manual)
FEBE1%DATA%GAINELE2	$n_{\rm bd}$	R	deg	Gain-elevation correction parameter 2 (see MBFITS manual)
FEBE1%DATA%GAINIMAG	$n_{\rm pix} \times n_{\rm bd}$	R		Gain ratio image/signal sideband
FEBE1%DATA%FLATFIEL	$n_{\rm pix} \times n_{\rm bd}$	R		receiver array flat field (relative gains)
FEBE1%DATA%BOLCALFC	$n_{\rm pix}$	R	Jy/counts	bolometer calibration factor
FEBE1%DATA%ANTGAIN	$n_{\rm pix} \times n_{\rm bd}$	R	K/Jy	Antenna gain
FEBE1%DATA%HPBW	$n_{\rm pix} \times n_{\rm bd}$	R	deg	Half-power beam width
FEBE1%DATA%ETAFSS	$n_{\rm pix} \times n_{\rm bd}$	R		forward efficiency
FEBE1%DATA%BEAMEFF	$n_{\rm pix} \times n_{\rm bd}$	R		beam efficiency
FEBE1%DATA%APEREFF	$n_{\rm pix} \times n_{\rm bd}$	R		aperture efficiency
FEBE1%DATA%POLA	$n_{\rm pix}$	R	deg	feed orientation
FEBE1%DATA%POLTY	$n_{\rm pix}$	C*1		feed type (X, Y, L, R)
FEBE1%DATA%REFFEED		I		feed number of reference feed
FEBE1%DATA%FEEDOFFX	$n_{\rm pix}$	D	deg	feed x offset
FEBE1%DATA%FEEDOFFY	$n_{\rm pix}$	D	deg	feed y offset
FEBE1%DATA%DATA%FEEDTYPE	$n_{\rm pix}$	C*1		feed type (see MBFITS manual)
FEBE1%DATA%USEFEED	$n_{\rm pix}$	I		list of feeds which are in use

5.4 ARRAY section

There is one ARRAY (= receiver array description) section per frontend-backend combination and per baseband. The following list is for frontend-backend combination 1 and baseband 1 (the corresponding structure names for frontend-backend combination 2 were FEBE2%HEADER1 and FEBE2%DATA1, respectively FEBE2%HEADER2 and FEBE2%DATA2 for baseband 2, and so on).

ARRAY1	S		
ARRAY1%HEADER1	S		
ARRAY1%HEADER1%VSYS4R_2	R	km/s	observer velocity in rest frame
ARRAY1%HEADER1%VSOU4R_2	R	km/s	source velocity in rest frame
ARRAY1%HEADER1%SOBS4R_2	C*8	'TOPOCENT'	observing frame
ARRAY1%HEADER1%SPEC4R_2	C*8	e.g. 'LSRK'	standard of rest frame for velocities
ARRAY1%HEADER1%CD4R_21	D	km/s	velocity channel separation
ARRAY1%HEADER1%CUNI4R_2	C*8	'km/s'	Unit
ARRAY1%HEADER1%CRVL4R_2	D	km/s	velocity at reference channel
ARRAY1%HEADER1%CRPX4R_2	R		reference channel
ARRAY1%HEADER1%CTYP4R_2	C*8	e.g. 'VARD-FRQ'	velocity axis for col.3
ARRAY1%HEADER1%WCSNM4R	C*8	e.g. 'LsrkVRad'	axis name
ARRAY1%HEADER1%SOBS4F_2	C*8	'TOPOCENT'	observing frame
ARRAY1%HEADER1%SPEC4F_2	C*8	e.g. 'LSRK'	standard of rest for frequencies
ARRAY1%HEADER1%CD4F_21	D	Hz	channel separation
ARRAY1%HEADER1%CUNI4F_2	C*8	'Hz'	Unit

ARRAY1%HEADER1%CRVL4F_2	D	Hz	frequency at reference channel in rest frame
ARRAY1%HEADER1%CRPX4F_2	R	Hz	reference channel.
ARRAY1%HEADER1%CTYP4F_2	C*8	'FREQ-FRQ'	frequency axis for col. 3
ARRAY1%HEADER1%WCSNM4F	C*8	e.g. 'LsrkFreq'	axis name
ARRAY1%HEADER1%CD3A_11	I		pixel index separation = 1
ARRAY1%HEADER1%CRVL4_1	I		pixel index value at this position = 1
ARRAY1%HEADER1%CRPX4_1	I		ref. position = 1
ARRAY1%HEADER1%CTYP4_1	C*8	'PIX-INDX'	Pixel/feed index in USEPIX array
ARRAY1%HEADER1%SBSEP	D	Hz	sideband separation
ARRAY1%HEADER1%SIDEBAND	C*3		main sideband (USB or LSB)
ARRAY1%HEADER1%RESTFREQ	D	Hz	rest frequency of line (optional)
ARRAY1%HEADER1%TRANSITI	C*20		main line transition (optional)
ARRAY1%HEADER1%MOLECULE	C*20		main line molecule (optional)
ARRAY1%HEADER1%BANDWID	D	Hz	bandwidth for this band
ARRAY1%HEADER1%FREQRES	D	Hz	frequency resolution
ARRAY1%HEADER1%CHANNELS	I		number of channels for this baseband
ARRAY1%HEADER1%DATE_OBS	C*23		observation start in TIMESYS system
ARRAY1%HEADER1%OBSNUM	I		observation number
ARRAY1%HEADER1%SCANNUM	I		scan number
ARRAY1%HEADER1%BASEBAND	I		baseband number
ARRAY1%HEADER1%FEBE	C*17		frontend-backend combination ID

ARRAY1%DATA1%ISWITCH	$n_{\rm rec}$	C*4		integration type NONE ON OFF LOAD SKY HOT COLD FHI FLO
ARRAY1%DATA1%MJD	$n_{\rm rec}$	D	day	MJD at integration midpoint in TIMESYS system
ARRAY1%DATA1%DATA	$n_{\rm pix} \times n_{\rm cpb} \times n_{\rm rec} \times n_{\rm ph}$	R		backend data

5.5 DATA section

There is one DATA section per frontend-backend combination. The following list is for frontend-backend combination 1 (the corresponding structure names for combination 2 were DATA2%HEADER and DATA2%DATA, and so on). Data associated parameters are interpolated from the monitor data (next section) at the MIDTIME timestamp of the backend data.

DATA1%HEADER	S		
DATA1%HEADER%CHANNELS	I		number of channels (for concatenated basebands)
DATA1%HEADER%OBSTATUS	C*10		Observation o.k. ? (OK/ABORT)
DATA1%HEADER%DPBLOCK	L		Data blocking ?
DATA1%HEADER%OBSTYPE	C*1		observation type (CAL, REF, ON, HOT, COLD, SKY)
DATA1%HEADER%LST	D	s	Local apparent sidereal time (obs. start)
DATA1%HEADER%DATE_OBS	C*23		observation start in TIMESYS system
DATA1%HEADER%OBSNUM	I		observation number
DATA1%HEADER%SCANNUM	I		scan number
DATA1%HEADER%FEBE	C*17		frontend-backend identification
DATA1%DATA%AZIMUTH	$n_{\rm rec}$ D	deg	azimuth inc. wobbler offsets
DATA1%DATA%BASLONG	$n_{\rm rec}$ D	deg	actual long. in astronomical basis frame, inc. wobbler offsets
DATA1%DATA%BASLAT	$n_{\rm rec}$ D	deg	actual lat. in astronomical basis frame, inc. wobbler offsets
DATA1%DATA%CBASLONG	$n_{\rm rec}$D	deg	commanded long. in astr. basis frame, inc. wobbler offsets
DATA1%DATA%CBASLAT	$n_{\rm rec}$D	deg	commanded lat. in astr. basis frame, inc. wobbler offsets
DATA1%DATA%ELEVATIO	$n_{\rm rec}$D	deg	elevation inc. wobbler offsets
DATA1%DATA%DFOCUS_X_Y_Z	$n_{\rm rec} \times 3$ D	mm	(opt.) focus offsets X, Y, Z (subrefl. position)
DATA1%DATA%FOCUS_X_Y_Z	$n_{\rm rec} \times 3$ D	mm	focus (subreflector position) X, Y, Z
DATA1%DATA%INTEGTIM	$n_{\rm rec}$ D	s	integration time
DATA1%DATA%INTEGNUM	$n_{\rm rec}$ I		integration point number
DATA1%DATA%LST	$n_{\rm rec}$ D	s	local apparent sidereal time
DATA1%DATA%LONGOFF	$n_{\rm rec}$ D	deg	long. offset from source in user native frame
DATA1%DATA%LATOFF	$n_{\rm rec}$ D	deg	lat. offset from source in user native frame
DATA1%DATA%MLONPOLE	$n_{\rm rec}$ D	deg	(opt.) longitude of basis celestial pole in body system
DATA1%DATA%MLATPOLE	$n_{\rm rec}$ D	deg	(opt.) basis latitude of body frame pole
DATA1%DATA%MCRVAL1	$n_{\rm rec}$ D	deg	(opt.) body apparent long. in basis system
DATA1%DATA%MCRVAL2	$n_{\rm rec}$ D	deg	(opt.) body apparent lat. in basis system
DATA1%DATA%MIDTIME	$n_{\rm rec}$ D	day	MJD at integration midpoint in TIMESYS system
DATA1%DATA%MJD	$n_{\rm rec}$ D	day	MJD at integration endpoint in TIMESYS system
DATA1%DATA%NINTS	$n_{\rm rec}$ I		integrations in block

DATA1%DATA%PHI_X_Y_Z	$n_{\rm rec}$	D	deg	Phi (subreflector rotation) X, Y, Z (see MBFITS manual)
DATA1%DATA%PC_11		D		matrix elements of transformation from pixel coordinates to intermediate pixel coordinates (projection of user frame)
DATA1%DATA%PC_12		D		
DATA1%DATA%PC_21		D		
DATA1%DATA%PC_22		D		
DATA1%DATA%PARANGLE	$n_{\rm rec}$	D	deg	parallactic angle
DATA1%DATA%SUBSCAN	$n_{\rm rec}$	I		subscan number of data point
DATA1%DATA%OTFDATA	$n_{\rm pix} \times n_{\rm chan} \times n_{\rm rec}$	R	counts, $T_{\rm A}^*$ [K]	OTF data with basebands concatenated and off subtracted
DATA1%DATA%RDATA	$n_{\rm pix} \times n_{\rm ch}$	R	counts, $T_{\rm A}^*$ [K]	single pointing data, basebands concatenated and off subtracted

5.6 MONITOR section

The MONITOR section describes all parameters associated with the data. MONITOR data are recorded independently from the backend data (DATA section). The interpolation of data associated parameters at the backend timestamps is written into the data substructure of the DATA section (see above).

MON	S		
MON%HEADER	S		
MON%HEADER%DATE_OBS	C*23		observing date in TIMESYS system
MON%HEADER%FOCOBS_X_Y_Z	3 D	mm	X,Y,Z focus correction
MON%HEADER%IAOBS_CAOBS_IEOBS	3 D	arcsec	Pointing corrections, to be added to IA (P1), CA (P2) and IE (P7). In old 30m control system terms: IAOBS = NULA, CAOBS = COL*, IEOBS = NULE
MON%HEADER%OBSNUM	I		observation number
MON%HEADER%SCANNUM	I		scan number

MON%DATA		S		
MON%DATA%REFRACTIO		D	arcsec	refraction correction
MON%DATA%THOTCOLD	2	D	K	hot & cold load temperature
MON%DATA%TAMB_P_HUMID	3	D	C, hPa, %	ambient temperature, pressure and rel. humidity
MON%DATA%ANTENNA_AZ_EL	2	D	deg	SAZM & SELV from old control system
MON%DATA%LONGOFF	n_{slow}	D	deg	long. offset from source in user native frame
MON%DATA%LATOFF	n_{slow}	D	deg	lat. offset from source in user native frame
MON%DATA%BASLONG	n_{slow}	D	deg	actual long. in astronomical basis frame, inc. wobbler offsets
MON%DATA%BASLAT	n_{slow}	D	deg	actual lat. in astronomical basis frame, inc. wobbler offsets
MON%DATA%PARANGLE	n_{slow}	D	deg	parallactic angle
MON%DATA%PHI_X_Y_Z	$n_{\mathrm{subr}} \times 3$	D	deg	Phi (subrefl. rotation) X, Y, Z (see MBFITS manual)
MON%DATA%FOCUS_X_Y_Z	$n_{\mathrm{subr}} \times 4$	D		focus offsets and timestamp:
			mm	X subreflector position
			mm	Y subreflector position
			mm	Z subreflector position
			day	MJD timestamp in IMBF–subreflector binary table
MON%DATA%DFOCUS_X_Y_Z	$n_{\mathrm{subr}} \times 3$	D	mm	focus (subreflector position) offsets X, Y, Z
MON%DATA%TRACKING_AZ_EL	$n_{\mathrm{fast}} \times 2$	D	deg	antenna tracking errors in azimuth and elevation
MON%DATA%ENCODER_AZ_EL	$n_{\mathrm{fast}} \times 3$	D		encoder azimuth & elevation and timestamp
			deg	encoder azimuth
			deg	encoder elevation
			day	MJD time of IMBF–antenna binary table (fast track)
MON%DATA%MJD	n_{slow}	D	day	MJD time of IMBF–antenna binary table (slow track)

5.7 GAINS section

The GAINS section is not a part of the MBFITS raw-data format, and contains information relevant to data calibration (together with the weather data, that are written to the MONITOR section). There is a separate GAINS section for each frontend-backend combination (i.e. GAINS1, GAINS2 etc.).

GAINS1%PCOLD	$n_{\rm bd} \times n_{\rm pix} \times n_{\rm cpb}$ D		backend count rate of cold load
GAINS1%PHOT	$n_{\rm bd} \times n_{\rm pix} \times n_{\rm cpb}$ D		backend count rate on ambient load
GAINS1%PSKY	$n_{\rm bd} \times n_{\rm pix} \times n_{\rm cpb}$ D		backend count rate on sky
GAINS1%LCALOF	D	deg	longitude offset for sky measurement
GAINS1%BCALOF	D	deg	latitude offset for sky measurement
GAINS1%TAUZEN	$n_{\rm bd} \times n_{\rm pix}$D	Np	zenith opacity
GAINS1%TAUZENIMAGE	$n_{\rm bd} \times n_{\rm pix}$ D	Np	zenith opacity in image band
GAINS1%TATMS	$n_{\rm bd} \times n_{\rm pix}$D	K	atmospheric emission temperature
GAINS1%TATMI	$n_{\rm bd} \times n_{\rm pix}$D	K	atmospheric emission temperature (image band)
GAINS1%TSYS	$n_{\rm bd} \times n_{\rm pix}$D	K	system temperature
GAINS1%TRX	$n_{\rm bd} \times n_{\rm pix}$ D	K	receiver temperature
GAINS1%H2OMM	$n_{\rm bd} \times n_{\rm pix}$D	mm	precipitable water vapour
GAINS1%GAINARRAY	$n_{\rm bd} \times n_{\rm pix} \times n_{\rm cpb}$ D		gain array (= PHOT−PSKY)
GAINS1%FEBE	C*17		frontend-backend identification

5.8 CHOICE section

The CHOICE section is not a part of the MBFITS raw-data format, and describes the selection criteria for MIRA's find command.

CHOICE	S	
CHOICE%TELESCOPE	C*13	
CHOICE%OBJECT	C*20	
CHOICE%SCAN1	C*4	first scan of selected scan range
CHOICE%SCAN2	C*4	last scan of selected scan range
CHOICE%PROCEDURE	C*8	observing procedure
CHOICE%DATE_OBS1	C*23	starting date for selection
CHOICE%DATE_OBS2	C*23	end date for selection
CHOICE%TRANSITION	C*20	spectral line name
CHOICE%FRONTEND	C*8	frontend selection
CHOICE%BACKEND	C*8	backend selection

5.9 REDUCE section

The REDUCE section is not a part of the MBFITS raw-data format, and contains MIRA-internal flags describing the calibration history. There is one REDUCE section per frontend-backend combination, i.e. REDUCE1, REDUCE2, etc.

REDUCE1	S	
REDUCE1%DESPIKE_DONE	L	Data despiked (yes/no) ?
REDUCE1%BASE_DONE	L	Baseline subtracted (yes/no) ?
REDUCE1%CALIBRATION_DONE	3 I	Calibration done ?
		(1) Normalized by gainarray (yes /no) ?
		(2) Backend count rates (no) or temp. scale (yes) ?
		(3) Off signal subtracted (yes /no) ?

5.10 RAW section

The RAW section is not part of the MBFITS raw-data format, and contains time stamps for subscan start and end in the IMBF raw-data. There is *one* RAW section per subscan (i.e. RAW1, RAW2,...).

RAW1	S		
RAW1%ANTENNA	S		structure for antenna monitoring data
RAW1%ANTENNA%SUBSCANTYPE	C*40		subscan type
RAW1%ANTENNA%SUBSCANSTART	D	day	subscan start (MJD in TIMESYS system)
RAW1%ANTENNA%SUBSCANEND	D	day	subscan end (MJD in TIMESYS system)
RAW1%ANTENNA%SEGMENTXSTART	D	deg	offset at subscan start on abscissa in user native system
RAW1%ANTENNA%SEGMENTXEND	D	deg	offset on abscissa at subscan end
RAW1%ANTENNA%SEGMENTYSTART	D	deg	offset at subscan start on ordinate in user native system
RAW1%ANTENNA%SEGMENTYEND	D	deg	offset on ordinate at subscan end
RAW1%SUBREF	S		structure for subreflector monitoring data
RAW1%SUBREF%SUBSCANSTART	D	day	subscan start (MJD in TIMESYS system)
RAW1%SUBREF%SUBSCANEND	D	day	subscan end (MJD in TIMESYS system)
RAW1%SUBREF%SEGMENTXSTART	D	deg	offset at subscan start on abscissa in user native system
RAW1%SUBREF%SEGMENTXEND	D	deg	offset on abscissa at subscan end
RAW1%SUBREF%SEGMENTYSTART	D	deg	offset at subscan start on ordinate in user native system
RAW1%SUBREF%SEGMENTYEND	D	deg	offset on ordinate at subscan end
RAW1%BACKEND	S		structure for backend data
RAW1%BACKEND%SUBSCANSTART	D	day	subscan start (MJD in TIMESYS system)

5.11 LIST section

The LIST section is not part of the MBFITS raw-data format, and contains the information in the current index list. LIST consists of LISTof observations found), and – for each observation – LISTLIST

LIST	S	
	S	
LIST%FOUND	I	number of observations in the current index list
LIST%ATTRIBUTE1	S	
LIST%ATTRIBUTE1%NCFE	I	number of connected frontends
LIST%ATTRIBUTE1%DATEOBS	C*23	scan start (yyyy-mm-ddThh:mm:ss.sss)
LIST%ATTRIBUTE1%BACKEND	C*8	backend name
LIST%ATTRIBUTE1%SWITCHMODE	C*20	switching mode
LIST%ATTRIBUTE1%PROCEDURE	C*8	observing procedure
LIST%ATTRIBUTE1%TELESCOPE	C*13	observatory /telescope name
LIST%ATTRIBUTE1%OBJECT	C*20	source name
LIST%ATTRIBUTE1%SCAN	I	scan number
LIST%ATTRIBUTE1%INDX	I	observation number

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